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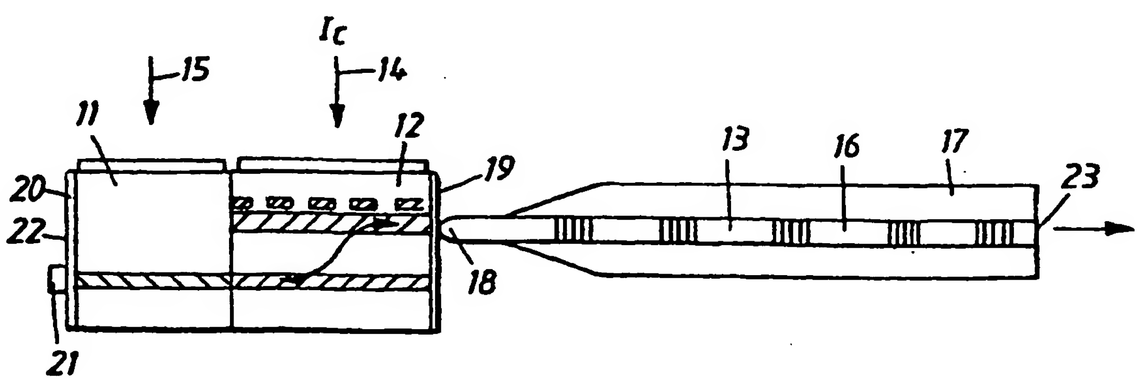

(57) Abstract

A tuneable laser that includes a gain section (11; 34) and a tuneable wavelength-selective filter (12; 27). The invention is characterised in that a reflection filter in the form of an external reflector (13) is adapted to give a number of fixed reflection maxima, where each maximum corresponds to a given wavelength. The reflection filter is adapted to coact with the tuneable filter and the laser is adapted to be tuned to lase at any selected one of said wavelengths, by tuning the tuneable filter (12; 27). The invention also relates to a method.

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A TUNEABLE LASER AND A METHOD OF TUNING THE SAME

The present invention relates to a tuneable laser and to a method of tuning the same.

Tuneable semiconductor lasers have several different sections through which current is injected. The lasers will typically have three or four sections. The wavelength, power and mode purity of the lasers can be controlled by adjusting the current in the various sections. Mode purity means that the laser shall find itself in an operating point, i.e. in a combination of the three or four injected drive currents, which is characterised by the laser being located far from a combination of drive currents in which so-called mode jumps take place and where lasing of the laser is stable and side mode suppression is high.

Different applications have special requirements with respect to wavelength control. In telecommunications applications one requirement is that once having set the drive current and temperature, the laser shall retain its wavelength with a very high degree of accuracy over a very long period of time. A typical accuracy is 0.1 nanometer while a typical time period is twenty years.

Various types of tuneable lasers are available, such as DBR lasers and GSCR lasers. These laser types are described briefly below.

A common feature of these types of lasers is that they are tuned by injecting current into one or more of the laser sections, whereby the lasers lase at different wavelengths for different combinations of current injection.

One problem with this type of lasers in which the wavelength is given by the set injected currents is that the precision with respect to frequency at an operating point is not equally as high as the precision, e.g., of a type of laser where the monolithic Bragg reflector has been replaced with an external reflector in the form of a sampled fibre grating. A fibre that has been doped with Erbium to obtain amplification and which has been provided with a sampled grating to provide wavelength selected feedback is one example of such a laser. A laser of this nature can be tuned by mechanically stretching or elongating the fibre. With respect to frequency, this provides a precision that could correspond to an S-DBR or a GCSR laser design that has a very long reflector cavity. For instance, the cavity would need to have a length of 4.3 millimetres in order to achieve a precision of 10 GHz. It would be very difficult to produce such cavities with sufficient precision, due to manufacturing difficulties of a technical nature.

One advantage with lasers of this type is that they lase at a very narrow and well-defined frequency. A serious drawback, on the other hand, is that such lasers must be tuned by influencing the grating mechanically.

Current control is highly beneficial for communication purposes. However, it is difficult to control the first mentioned type of laser to lase in a pure mode and with high precision at a given frequency. This difficulty increases with ageing of the laser.

The present invention provides a laser that has the advantages of a laser which includes an external reflector while eliminating those drawbacks associated with such a

laser, by virtue of enabling the laser to be tuned by current control instead of by mechanical actuation.

The present invention thus relates to a tuneable laser that includes a gain section and a tuneable, wavelength selective filter, and is characterised in that a reflection filter in the form of an external reflector is adapted to deliver a number of fixed reflection maxima, wherein each maximum corresponds to a given wavelength and wherein said reflection filter is adapted to coact with said tuneable filter; and in that the laser is constructed to be tuned such as to lase at any one of said wavelengths, by tuning the tuneable filter.

The invention also relates to a method of the kind defined in Claim 12 and having essentially the characteristic features set forth in said Claim.

The invention will now be described in more detail with reference to exemplifying embodiments thereof and also with reference to the accompanying drawings, in which

- Figure 1 illustrates a partially cut-away known DBR laser in perspective;

- Figure 2 is a sectional view of a tuneable known grating coupled sampled reflector (GCSR) laser;

- Figure 3 illustrates a first embodiment of an inventive laser;

- Figure 4 is a block diagram illustrating a control circuit;

- Figure 5 illustrates diagrammatically the laser output power as a function of the current through the coupler section;

- Figure 6 is a diagrammatic illustration of the laser output power as a function of transmitted wavelength; and

- Figure 7 illustrates a second embodiment of an inventive laser.

Figure 1 illustrates a DBR laser that includes three sections, these being a Bragg reflector 1, a phase section 2 and a gain section 3. Each section is activated by injecting current thereinto via a respective electric conductor 4, 5, 6.

Figure 2 is a sectional view of a tuneable grating coupled sampled reflector (GCSR) laser. A laser of this kind has four sections, these being a Bragg reflector 7, a phase section 8, a coupler 9 and a gain section 10. Each of the sections is activated by injecting current into respective sections.

When the tuning currents, i.e. the currents injected into the different sections, are changed, the wavelength of the laser, the side mode suppression and the optical power of the laser will also be changed. In particular, the voltage across the active laser section will depend on whether or not the laser finds itself at a good operating point or close to a mode jump.

The laser will operate in accordance with a given mode and will give rise to different generated powers and different wavelengths with different tuning current combinations, For instance, if the Bragg current, i.e. the tuning current

through the Bragg section, is swept, the laser will pass through a series of mode jumps. The wavelength changes incrementally with each of these mode jumps. Side mode suppression is good between the mode jumps and poor at a mode jump. Thus, the laser shall be caused to have an operating point which lies far away from a mode jump.

Figures 3 and 7 illustrate respectively two different tuneable lasers according to the invention. The invention is not limited to these laser designs, but can also be applied with lasers of other types.

The laser shown in Figure 3 includes a gain section 11 and a coupler section 12 of the kind found with a GCSR laser.

The laser according to Figure 7 includes a reflector 27 that has a modulated Bragg grating, a phase section 28 and a gain section 29, in other words this part of the laser is of the type shown in Figure 1.

Both lasers thus include a gain section 11; 29 and a tuneable wavelength-selective filter 12; 27.

According to the invention, there is provided a reflection filter in the form of an external reflector 13 which is adapted to give a number of fixed reflection maxima, where each maximum corresponds to a given wavelength, said reflection filter being adapted to coact with said tuneable filter. The laser is adapted to be tuned to lase at any one of said wavelengths, by tuning the tuneable filter.

According to a first preferred embodiment of the invention, the tuneable filter is comprised of a coupler section 12 to which the gain section 11 is connected and to which the

external reflector 13 is connected on the opposite side thereof. This embodiment is shown in Figure 3.

The laser according to Figure 3 is adapted to be tuned to lase at any one of said wavelengths, by varying the current I through the coupler section 12. The current injected is illustrated by the arrow 14. The arrow 15 illustrates the current injected into the gain section 11.

According to a second preferred embodiment of the invention, shown in Figure 7, the tuneable filter is comprised of a modulated Bragg reflector 27, where a gain section 29 is located between the Bragg reflector and said external reflector 13.

The laser according to Figure 7 is adapted to be tuned to lase at any selected one of said wavelengths, by varying the current I through the reflector 27. The current injected is illustrated with the arrow 33, while the arrow 34 illustrates the current injected into the gain section 29 and the arrow 35 illustrates the current through the phase section 28.

The tuneable filter 12; 27 and said gain section 11; 29 will preferably be comprised of semiconductor material.

The tuneable filter 12; 27 and said gain section 11; 29 will also preferably be implemented in a monolithic component.

According to one preferred embodiment, the tuneable filter 12; 27 is adapted to be tuned by varying the current through the tuneable filter.

9 by

According to an alternative and also preferred embodiment, the tuneable filter 12; 27 is adapted to be tuned by varying the temperature of the filter.

The external reflector 13 will preferably include a modulated Bragg grating.

Furthermore the external reflector 13 will preferably comprise a dielectric light waveguide 16 provided with a modulated Bragg grating.

In this respect, it is particularly preferred that said light waveguide is comprised of fibreglass 16 formed into a lens 18, or has a narrowing part at that end connected to the laser.

The fibreglass core is coated with a cladding layer 17.

The fibre 16 is treated conventionally to reduce reflections.

The surface of the coupler section 12 that faces towards the fibre 16 has applied thereon a layer 19 of anti-reflection agent. A highly reflective layer 20 is provided on the free end surface of the gain section.

As a result of the described laser designs, the lasers will only be able to lase at those reflection peaks that are determined by the external reflector with fixed reflection peaks.

Such an external grating can be produced with a precision that is so high that the laser will lase at a given wavelength with very high precision, such as a precision of +/-1 GHz.

With respect to communication lasers, the grating is suitably constructed to enable the laser to lase at all of the frequency channels used by the communication system concerned. The number of channels used is normally from 8 to 32.

According to one embodiment of the present invention, the channel desired, i.e. the desired frequency, as mentioned above, is set by adjusting the current through the tuneable filter, which is the coupler section in the Figure 3 embodiment and the reflector 27 in the Figure 7 embodiment.

According to the aforesaid alternative embodiment, a desired channel is set by varying the temperature of the tuneable filter 12; 27. This is effected in a known manner, by coating the upper side of the filter with an electrically conductive material 36, as illustrated in broken lines in Figure 7, instead of an electrode 37 for injecting current into the filter as in the case of current control. Current is sent into one end of the layer 36 and taken out at the other end, as indicated by the arrows 38, 39. The heat generated in the layer 36 and therewith the temperature of the filter is varied by varying the current conducted through the layer. Naturally, a corresponding temperature regulation can be effected in the coupler section of the Figure 3 embodiment.

Thus, the invention provides a laser that has the advantages of tuneable lasers, namely frequency setting by current control, without the drawbacks of such lasers with regard to frequency accuracy, combined with the advantages of single-mode lasers with respect to high frequency precision.

According to one highly preferred embodiment of the invention, a monitor diode 21 which functions to measure the laser output power is placed at the rear side of the laser, i.e. at the free end-surface 22. The laser light is led out from the laser at the free end 23 of the external reflector.

Figure 4 is a schematic block diagram illustrating a control means forming part of the invention. The reference numeral 23 identifies a microprocessor with an associated memory 24. The memory is a random access memory (RAM). The microprocessor is of some suitable known kind. Some other suitable circuit may be used instead of a microprocessor, such as an application specific integrated circuit (ASIC). The microprocessor is adapted to activate the sections 11, 12; 27, 28, 29 individually with respect to injected current, via conventional current generators 25, 26 connected to respective sections. The monitor diode 21 is of a conventional kind. The monitor diode is adapted to measure laser transmission power and to deliver to the microprocessor 25 a signal which is relative to the transmission power, via a conductor 27.

According to one embodiment, activation of the laser coupler section is measured as the current that passes through the section. This measuring procedure is effected with conventional means.

According to an alternative embodiment, activation of the laser coupler section is measured on the basis of the voltage that prevails across the sections. This measuring process is effected with the aid of conventional means.

Figure 5 is a schematic diagrammat of the laser output power (P) as a function of the current (I_c) through the coupler

section 12. It will be seen that the power varies periodically, where each maximum corresponds to a wavelength at which the laser lases. Correspondingly, the output power varies with the current through the filter 27 in the case of the laser constructed in accordance with Figure 7.

Figure 6 is a diagram which shows that the output power of the laser is high solely at a number of well-defined wavelengths. Because the laser solely lases at very well-defined wavelengths, the output power is spiked in Figure 6, where each spike has a width of, e.g., +/-1 GHz. The different wavelengths at which the laser lases can be detected very easily by means of the monitor diode.

The present invention also relates to a method of tuning a laser of the aforedescribed kind.

According to the inventive method, a laser that includes a gain section and a tuneable wavelength-selective filter is tuned by causing a reflection filter which has the form of an external reflector 13 and which is adapted to give a plurality of fixed reflection maxima, where each maximum corresponds to a given wavelength, to coact with said tuneable filter, and by tuning the laser to lase at any one of said wavelengths by tuning the tuneable filter.

According to a first preferred method, a monitor diode 21 is adapted to measure the laser output power, where the current through the tuneable filter 12; 27 or the voltage across said tuneable filter is caused to increase successively from zero as the laser output power is measured by the monitor diode 21, wherewith the output power passes through a number of maxima, each of which corresponds to a given wavelength, and where the current passing through the tuneable filter or the

voltage across said filter is set so that the laser will lase at any one of said wavelengths.

According to a second, alternative preferred method, a monitor diode 21 is adapted to measure the laser output power, wherein the temperature of the tuneable filter 12; 27 is caused to increase successively from a predetermined start temperature as the laser output power is measured by means of the monitor diode 21, and wherein the temperature of the tuneable filter is set so that the laser will lase at any one of said wavelengths.

According to a first embodiment of the method, the output signal of the monitor diode is stored in the microprocessor and also the current through the coupler section, or the voltage across said coupler section, at each output power maximum is stored in said microprocessor together with the ordinal number of the maximum concerned.

The laser can then be readily adjusted to lase at a given wavelength corresponding to a given ordinal number, by causing the microprocessor to activate the current generator 25 with a current that causes the laser to lase at a desired wavelength from those wavelengths that are available.

According to one preferred embodiment, the output signal of the monitor diode 21 is stored in a microprocessor or corresponding device, wherein the current through the tuneable filter 12; 27, the voltage across the tuneable filter or the temperature of the tuneable filter at each output power maximum are stored together with the ordinal number of the maximum concerned.

According to a further preferred embodiment, the number of through-passed output power maxima is counted whilst the current through the tuneable filter 12; 27, the voltage across the tuneable filter or the temperature of the tuneable filter is/are caused to increase successively. Tuning of the filter is stopped, when the ordinal number of a predetermined maximum is reached.

According to one advantageous embodiment, the operating point of the laser can be finely optimised automatically, by applying a modulation signal to the tuneable filter.

The power measured via the monitor detector varies with the current across the tuneable filter and will have an extreme value when the power measured is optimal. By multiplying the coupler current modulation by the measured power, there is obtained a signal which indicates the direction in which the current shall flow through the coupler section.

The invention has been described above with reference to a number of exemplifying embodiments. It will be understood, however, that the laser can be modified without departing from the concept of combining a tuneable wavelength-selective filter with an external reflector so as to obtain a laser that has a plurality of fixed lasing frequencies.

The present invention shall not therefore be considered to be limited to the aforedescribed embodiments, since variations and modifications can be made within the scope of the following Claims.

CLAIMS

1. A tuneable laser that includes a gain section (11; 34) and a tuneable wavelength-selective filter (12; 27), **characterised** by a reflection filter in the form of an external reflector (13) adapted to give a plurality of fixed reflection maxima, where each maximum corresponds to a given wavelength, said reflection filter being adapted to coact with said tuneable filter; and in that the laser can be tuned to lase at any one of said wavelengths, by tuning the tuneable filter (12; 27).

2. A tuneable laser according to Claim 1, **characterised** in that the tuneable filter (12; 27) and the gain section (12; 34) are comprised of semiconductor material.

3. A tuneable laser according to Claim 2, **characterised** in that the tuneable filter (12; 27) and the gain section (12; 34) are implemented in a monolithic component.

4. A tuneable laser according to Claim 1, 2 or 3, **characterised** in that the tuneable filter (12; 27) is adapted to be tuned by varying the current through the tuneable filter.

5. A tuneable laser according to Claim 1, 2 or 3, **characterised** in that the tuneable filter (12; 27) is adapted to be tuned by varying the temperature of the filter.

6. A tuneable laser according to Claim 1, 2, 3, 4 or 5, **characterised** in that the external reflector (13) includes a modulated Bragg grating.

7. A tuneable laser according to Claim 1, 2, 3, 4, 5 or 6, **characterised** in that the tuneable filter is comprised of a coupler section (12) to which the gain section (11) is connected and to the opposite side of which the external reflector (13) is connected.

8. A tuneable laser according to Claim 1, 2, 3, 4, 5 or 6, **characterised** in that the tuneable filter is comprised of a modulated Bragg reflector (27), wherein a gain section (29) is located between the Bragg reflector and said external reflector (13).

9. A tuneable laser according to Claim 1, 2, 3, 4, 5, 6, 7 or 8, **characterised** in that the external reflector (13) is comprised of a dielectric light waveguide (16) that includes a modulated Bragg grating.

10. A tuneable laser according to Claim 9, **characterised** in that said light waveguide is a fibreglass structure (16) in the form of a lens (18) or has a tapering part at the end connected to said laser.

11. A tuneable laser according to any one of the preceding Claims, **characterised** by a monitor diode (21) which is adapted to measure the laser output power and which is placed at the rear side (22) of said laser, i.e. on the side opposite to that to which the external reflector (13) is connected.

12. A method of tuning a laser that includes an gain section (11) and a tuneable wavelength-selective filter (12; 27), **characterised** by causing a reflection filter in the form of an external reflector (13) and adapted to give a plurality of fixed reflection maxima where each maximum corresponds to a

given wavelength, to coact with said tuneable filter (12; 27); and by causing the laser to be tuned to lase at any of said wavelengths, by tuning the tuneable filter.

13. A method according to Claim 12, **characterised** by causing a monitor diode (21) to measure the laser output power; successively increasing the current through the tuneable filter (12; 27) or the voltage across said tuneable filter from zero whilst measuring the laser output power by means of said monitor diode (21), wherewith the output power passes through a number of maxima where each maximum corresponds to a given wavelength; and by adjusting the current through the tuneable filter or the voltage across said tuneable filter so that the laser will lase at any one of said wavelengths.

14. A method according to Claim 12, **characterised** by causing a monitor diode (21) to measure the laser output power; successively increasing the temperature through the tuneable filter (12; 27) from a predetermined start temperature whilst the monitor diode (21) measures the laser output power; and adjusting the temperature of the tuneable filter so that the laser will lase at any one of said wavelengths.

15. A method according to Claim 13 or 14, **characterised** by storing the output signal of the monitor diode (21) in a microprocessor or corresponding device; and by storing the value of the current through the tuneable filter (12; 27), the value of the voltage across the tuneable filter or the temperature of said tuneable filter at each output power maximum together with the ordinal number of the maximum concerned.

16. A method according to Claim 15, **characterised** by counting the number of through-passed maxima whilst

successively increasing the current through the tuneable filter (12; 27), the voltage across the tuneable filter or the temperature of said tuneable filter; and terminating tuning of said filter when the ordinal number of a predetermined maximum has been reached.

Fig. 1

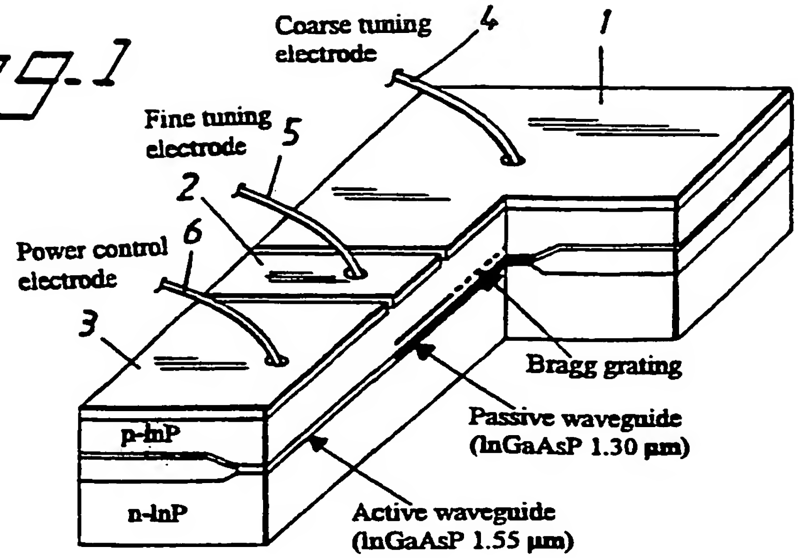


Fig. 2

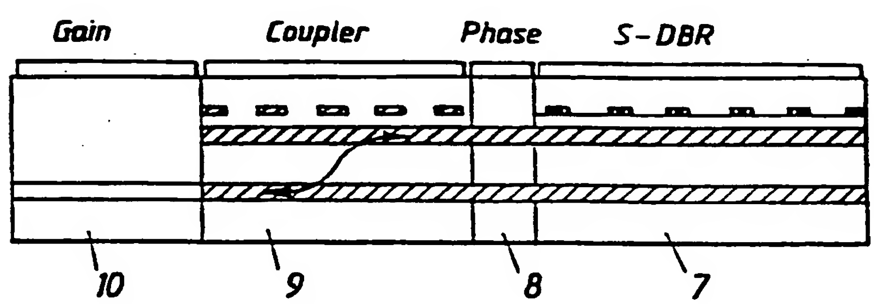


Fig. 3

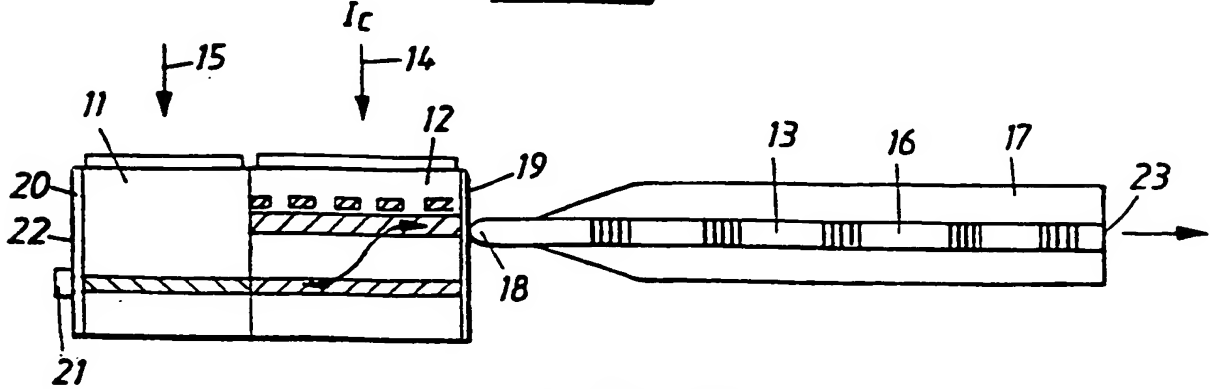


Fig. 4

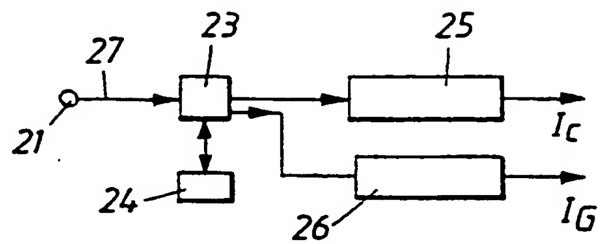


Fig. 5

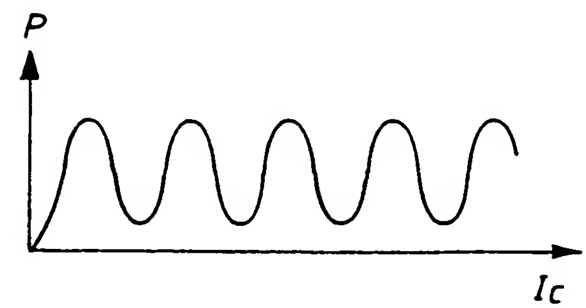
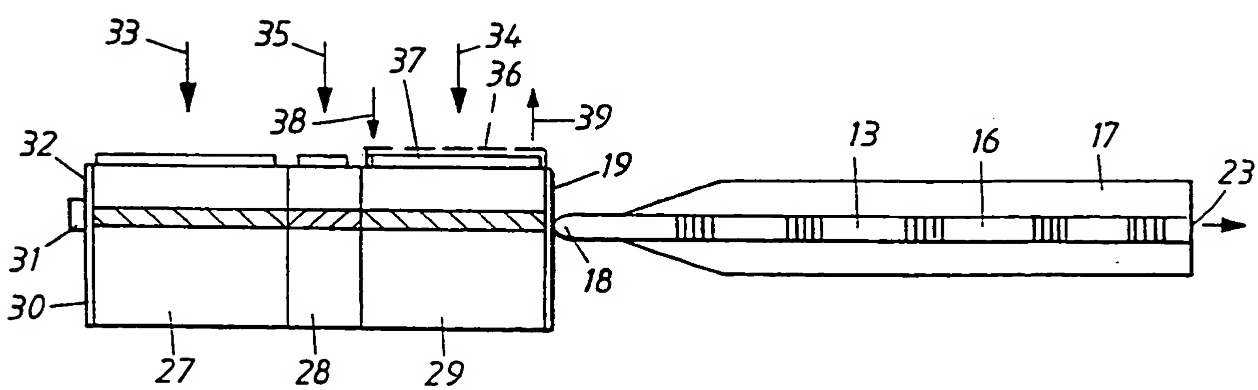


Fig. 6

Fig. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01715

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01S 5/026

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5828688 A (ANTHONY L. COOK ET AL), 27 October 1998 (27.10.98) --	1
A	US 5463647 A (JING-JONG PAN), 31 October 1995 (31.10.95) --	1
A	US 5442651 A (MINORU MAEDA), 15 August 1995 (15.08.95) --	1
A	US 5305336 A (RENEN ADAR ET AL), 19 April 1994 (19.04.94) --	1

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 March 2000	17-03-2000
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4955028 A (RODNEY C. ALFERNESS ET AL), 4 Sept 1990 (04.09.90) -- --------	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SE 99/01715

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5828688 A	27/10/98	NONE	
US 5463647 A	31/10/95	NONE	
US 5442651 A	15/08/95	DE 4332633 A,C	31/03/94
		FR 2696286 A,B	01/04/94
		GB 2271463 A,B	13/04/94
		JP 6112583 A	22/04/94
US 5305336 A	19/04/94	EP 0611097 A	17/08/94
		JP 6291423 A	18/10/94
		EP 0553994 A	04/08/93
		JP 6005961 A	14/01/94
US 4955028 A	04/09/90	NONE	